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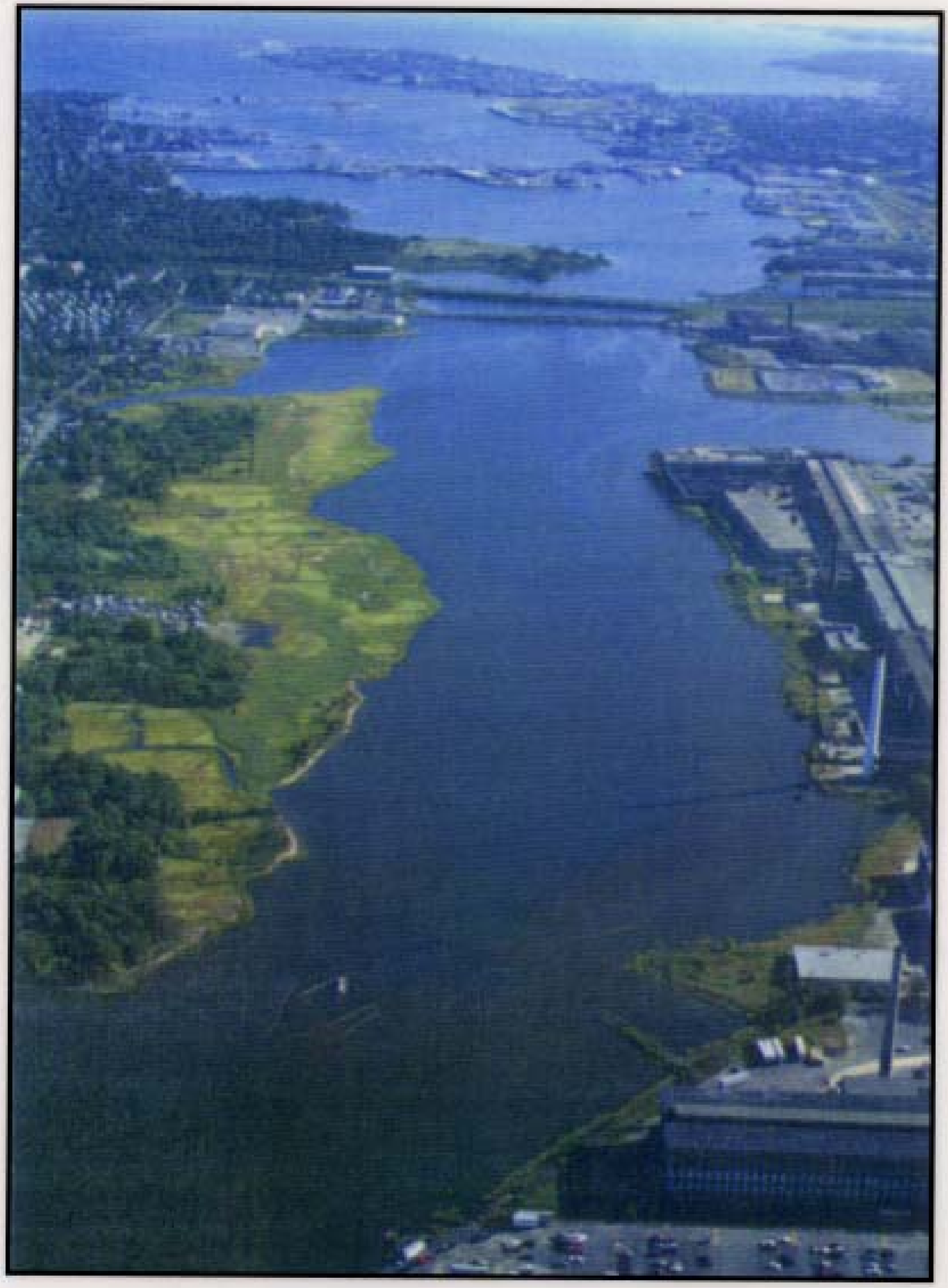
Report on the Effects of the Hot Spot Dredging Operations
New Bedford Harbor Superfund Site
New Bedford, Massachusetts



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I. Executive Summary

Industrial development surrounding New Bedford Harbor in southeastern Massachusetts has resulted in the harbor sediments becoming contaminated with high concentrations of many compounds, including polychlorinated biphenyls (PCBs) to greater than 100,000 ppm (Nelson et al., 1996). As a consequence of this contamination, the harbor and 17,000 acres of adjacent area in Buzzards Bay were finalized on the U.S. Environmental Protection Agency's (EPA's) National Priority List as a Superfund site in 1983. Among other remedial studies, a pilot dredging and disposal study conducted in 1988-1989 determined that hydraulic cutterhead dredging was effective in reducing sediment PCB concentrations and minimizing the release and transport of contaminants to acceptably low levels (USACE, 1990). In 1990, dredging was selected to remove the most contaminated sediments, approximately 5 acres referred to as the hot spots (USEPA, 1990).

Dredging of these hot spot sediments occurred from April 1994 through September 1995. Approximately 14,000 cy of sediments were hydraulically dredged and pumped via floating pipeline to an interim shoreline confined disposal facility (CDF) located about one mile away (Figure 2-1). In order to verify that dredging operations did not present undue risks to human health or the environment, extensive air and water quality monitoring was performed throughout project implementation. This report summarizes the results of these monitoring programs, and reviews the overall adverse effects, or lack thereof, associated with the dredging operations as demonstrated by a comparison of the monitoring results with pre-established control criteria.

The hot spot sediments were situated in a shallow tidal estuarine area where the Acushnet River merges with upper New Bedford Harbor (Figure 2-1). These sediments are generally a fine-sandy silt with some clay, and by definition contained greater than 4,000 ppm (0.4%) total PCBs. Cadmium, chromium, copper and lead were also present at high levels. Removal of the hot spot sediment was estimated to result in removal of approximately 45% of the total mass of PCBs in the harbor (Ebasco, 1989 at ES-2 and 2-6; USEPA, 1990 at 8).

The air and water quality monitoring results discussed herein were reviewed continually throughout implementation to ensure a safe project, and to make operational adjustments as appropriate. In summary, while little if any adverse impacts to the marine ecosystem were found, some issues with air quality arose that were addressed through changes in operation or through engineering controls. Only 10 of over 4,000 airborne PCB samples (0.25%), taken at 16 separate monitoring stations, exceeded the 1 ug/m^3 recommended exposure limit (REL) for each individual Aroclor (NIOSH, 1994).

The Record of Decision for this first operable unit at the site originally called for on-site incineration of the dredged hot spot sediments. However, due to a vehement and congressionally supported reversal in public support for incineration at about the mobilization stage, EPA terminated the incineration component of the remedy. EPA is currently developing an alternative treatment or disposal remedy for the dredged sediments. In the interim, the sediments remain stored in the hot spot CDF.

The high degree of public interest in the project also carried over to the dredging portion of the remedy. EPA, the Commonwealth of Massachusetts and the U.S. Army Corps of Engineers (USACE, COE or the Corps) worked extensively with interested local stakeholders throughout project operations to share monitoring data on a quick turn-around basis, and to demonstrate that the project was being performed in an environmentally sound manner.

As with the implementation of the dredging project, production of this report was a collaborative effort between EPA Region I, EPA's Narragansett, RI marine research and development laboratory, USACE and their consultant Roy F. Weston, Inc. Questions regarding this report may be directed to David Dickerson, EPA's Remedial Project Manager for the site at 617/573-5735 or dickerson.dave@epamail.epa.gov.

II. Summary of the Environmental Effects of the Hot Spot Dredging Program

A. Introduction

One of the principal goals of the hot spot dredging program was the removal of a significant percentage of the PCB mass in the upper harbor without causing significant additional risks to human health or the environment. A second objective was to avoid additional remediation in the lower harbor as a result of the dredging program (i.e., contaminant transport to less contaminated areas). A monitoring plan was developed prior to dredging based on these project goals (Nelson, et al., 1994). Specific criteria were established to ensure that this operation did not pose a threat to human health or cause additional environmental damage to New Bedford Harbor (NBH) and adjacent Buzzards Bay.

This section is structured to follow the decision criteria listed in the original monitoring plan. Specific criteria were established for the net transport of PCBs from the upper harbor as well as for selected biological parameters (toxicity tests and bioaccumulation). Chemical and physical criteria addressed concerns with respect to limiting the transport of contaminants from the more severely contaminated upper harbor. Biological criteria, including selected toxicity tests and PCB bioaccumulation in blue and ribbed mussels (*Mytilus edulis* and *Modiolus demissus*, respectively), were established to ensure that biota were not adversely affected. In addition, PCBs and metals were monitored in the water column. The specific criteria and methods utilized will be described, followed by a discussion of the results relative to the established criteria. Finally, all the data will be considered relative to the overall project goals, thus providing an information base upon which to assess the success of the Hot Spot dredging project as well as dredging as a remedial option for additional contaminated sediments in NBH.

B. Methods

The location of monitoring stations critical to the environmental criteria, and the rationale for various criteria selection, are described in detail and are similar to those used during the pilot dredging study (Nelson and Hansen, 1991).

Station Location

One fundamental goal associated with decision-making during remediation was to limit contaminant transport, and subsequent effects, from the upper harbor to the lower harbor and Buzzards Bay (Figure 2-1). Therefore, decision criteria were established to limit effects at the same two strategic stations employed in

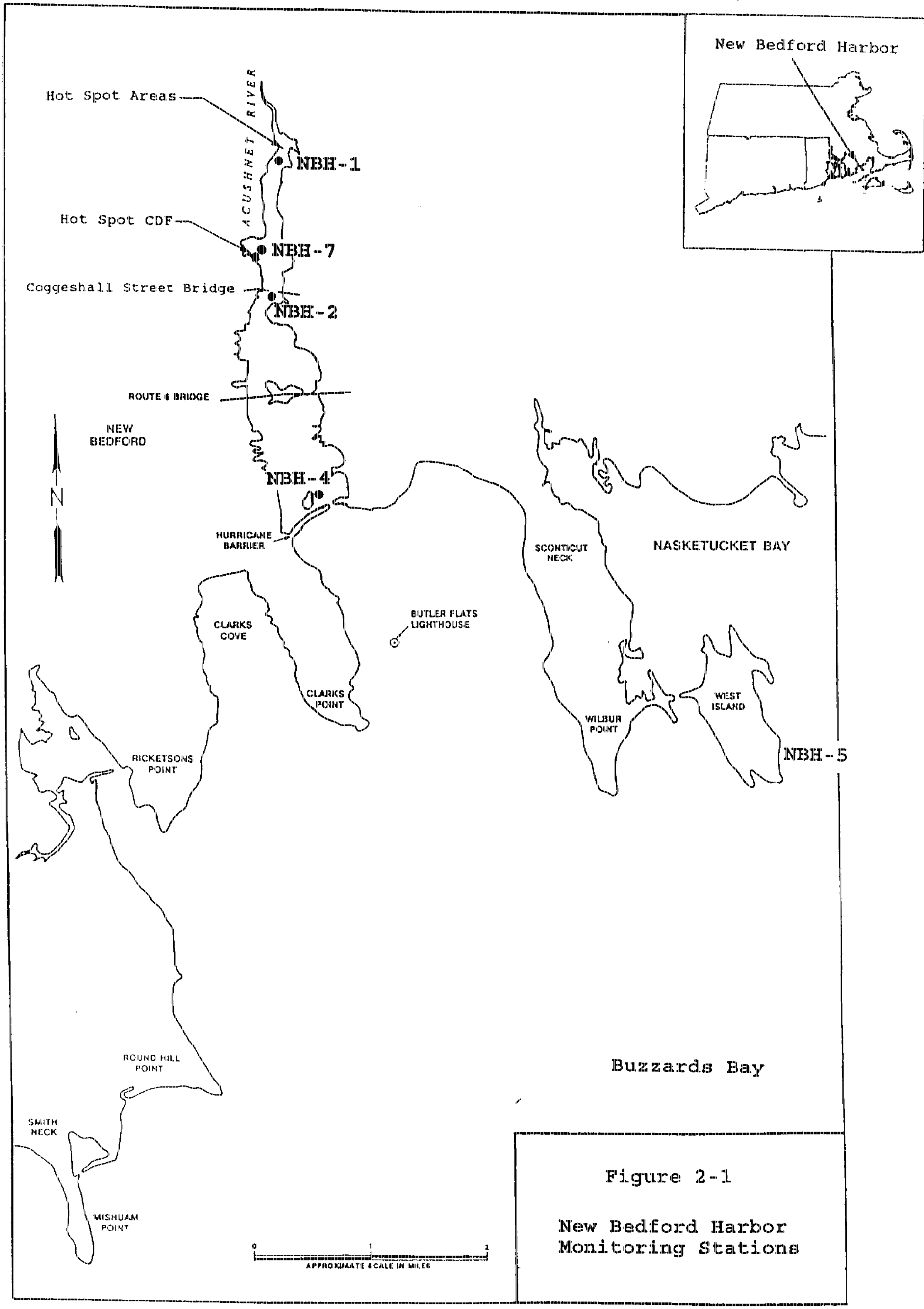


Figure 2-1

New Bedford Harbor Monitoring Stations

the pilot study, the Coggeshall St. Bridge (NBH-2) and the Hurricane Barrier (NBH-4). Station NBH-2 is positioned at the transition between the upper and lower harbor; criteria were established here to limit the net transport of PCBs to the lower harbor, monitor for significant PCB bioaccumulation in mussels, and monitor for acute toxicity in the water column. At Station NBH-4, the transition point between NBH proper and Buzzards Bay, decision criteria were established for PCB bioaccumulation in mussels as well as for sub-lethal biological effects. Unlike the pilot study, no chemical criteria for water column samples were established at NBH-4. Chemical data collected during the pilot study indicated that when concentrations were controlled at NBH-2, no corresponding signal was observed at NBH-4. Because PCB net transport was monitored at NBH-2, it was not necessary to measure chemical concentrations in the water column at NBH-4. Additionally, mussel bioaccumulation was quantified at NBH-4, which provided an integrated assessment of water column PCB concentration over time.

In addition to the stations sampled for the decision criteria, supplemental water column monitoring occurred at several other upper harbor locations. The additional stations were sampled to assist in identifying possible causes of potential toxicity associated with the operation. These stations included one immediately south of the dredging operation, NBH-1, and one in the vicinity of the CDF, NBH-7. For example, if toxicity was noted at NBH-2, conceivably it could be associated with either the dredging operation or the CDF effluent. Without monitoring at these additional sites to distinguish the toxic stream location, the observed toxicity might be attributed to dredging when it could have been emanating from the CDF.

Decision Criteria

Net Transport

As stated previously, one goal of the hot spot remediation was to minimize the transport of contaminants to the lower harbor. To accomplish this objective, PCB transport under the Coggeshall Street Bridge needed to be limited. Previous studies by the COE, EPA, and others have demonstrated a continual net transport of PCBs to the lower harbor even in the absence of dredging. Because PCB net transport occurs continuously, regardless of remedial operations, it was necessary to establish some "acceptable" criterion limit for transport associated with the hot spot remediation. This level was selected to ensure that no additional remediation in the lower harbor would be required.

While the idea of limiting dredging-related PCB transport was desirable, establishing a specific criterion value was less straightforward. Several approaches were possible. During the pilot study, the PCB criterion at NBH-2 was based on a daily single-point water column concentration measurement compared against a statistically significant increase over preoperational conditions (Nelson and Hansen, 1991). This approach worked well for several reasons. First, the sediment PCB concentrations were relatively low (~200 $\mu g/g$) and the duration of the project was short. Therefore, the probability of transporting large amounts of PCBs to the lower harbor was low and could be controlled effectively by assessing PCB concentrations at NBH-2 on a daily basis against a single point criterion.

This was not the case with the hot spot remediation. The sediment concentrations were up to three orders of magnitude higher than those dredged during the pilot study, and the duration of the project was longer. Therefore, a single episodic criterion value could give a false sense of security with respect to PCB transport to the lower harbor. For example, if the PCB water column concentration remained at 1.3 $\mu g/l$ during the entire hot spot remediation, a period of about 16 months, it would not have constituted a violation relative to the pilot study decision criterion of 1.4 $\mu g/l$. However, if PCB water concentrations were near background most of the time (~0.3 $\mu g/l$ during the dredging period), and exceeded the old criterion only intermittently during the operation, the net transport of PCBs into the lower harbor would be less over time. Therefore, it was important to consider both magnitude (i.e., concentration) and duration (i.e., time) components for the hot spot remediation. An evaluation parameter that provided the most integrative assessment of PCB transport would yield the greatest probability of limiting lower harbor impact during the remedial operation. A more conservative (i.e., environmentally protective) approach than the single episodic value was adopted for the hot spot remediation; a maximum cumulative transport (MCT) of PCBs during the entire operation. This MCT approach was based on the belief that some quantity of PCBs could be calculated that would be presumed to have no significant impact on the lower harbor. This mass of PCBs became the decision criterion value. The cumulative total of PCB net transport at NBH-2 was then compared with this upper limit throughout the operation.

The challenge in proposing a MCT for PCBs at NBH-2 was defining that mass of PCBs which would be "unacceptable" for transport to the lower harbor. A scientifically defensible estimate of how much PCB transport is "acceptable" is very difficult, if not impossible, to calculate. Consequently, best professional judgement was exercised to define an "unacceptable" MCT to meet the objective of not requiring additional remediation in the lower harbor. The average sediment concentration in the lower harbor was calculated to be 14 ppm (Nelson et al., 1994). Based on this existing average concentration, it was decided that a 1 ppm increase in the sediment would probably neither be detectable analytically nor cause additional damage ecologically. Therefore, the MCT criterion value for NBH-2 was operationally defined as follows: <u>that mass of PCBs transported out from the upper harbor, above background concentrations, that would increase the mean lower harbor sediment concentration by more than 1 ppm</u>.

Based on this definition, a numerical MCT criterion value was calculated. Several assumptions were made. First, it was assumed that PCBs would be deposited in the sediment uniformly over the entire lower harbor and remain in the system indefinitely. This was not the case. Data collected before, during, and after the pilot study indicate that only about 50% of the total PCBs at NBH-2 are associated with particulates. The other half are present in the dissolved phase of the water and would likely not settle to the bottom, especially exclusively in the lower harbor. Also, a portion of those particles that move into the lower harbor may deposit in the depositional areas presently scheduled for remediation (USEPA, 1996b). This mass of PCBs will be removed permanently from the lower harbor and not have a long-term impact. Finally, the MCT approach assumed that only PCBs would deposit during the operation. In fact, uncontaminated particles also deposit continuously, which has the cumulative effect of diluting any PCBs that will be deposited as a result of the remediation. Therefore, the assumption that all PCBs that are "allowed" to be transported using the MCT approach will remain in the sediments of the lower harbor is conservative on the side of environmental protection.

The calculation of the MCT value required the determination of the mass of PCBs in lower NBH. A detailed description is given by Nelson et al. (1994); however, a brief overview is provided here. The total sediment surface area in the lower harbor was determined using a digitizing planimeter. Next, the volume of sediment was determined by multiplying the area by a depth of 4 cm; chosen to represent the biologically active zone. The resultant volume was converted to dry weight mass units using an estimate of sediment density (1 cubic cm = 2.2 g dry wt). The total mass of the top 4 cm of sediment in the lower harbor was approximately 240 X 10^6 Kg. Therefore, in order to increase the total PCB sediment concentration by 1 ppm, 240 Kg of PCB would have to be transported to the lower harbor. This mass of PCBs became the MCT decision criteria value for NBH-2.

<u>Biological</u>

In addition to the chemical and physical measurements, biological decision criteria serve two purposes: a reality check on the chemical criteria and a screen for the presence of toxicity associated with contaminants not monitored for chemically. Typically, the general public can relate more closely to biological measurements than chemistry numbers. The fact that there are a few additional μg of a contaminant in the water column often does not convey much significance to the public. However, if those contaminants cause mortality in the biota, a red flag is raised in peoples' minds. Conversely, a small increase in contaminant concentrations without a corresponding biological signal indicates that those elevated levels may not be causing significant environmental impacts. This was the case during the pilot study. The biological criteria indicated no impact at the two stations at which they were employed, even when sporadic elevation in PCBs occurred at NBH-2. These values provided a reality check for the chemical values and a sense of security that environmental parameters of concern, namely the health of the biota, were being protected.

A second rationale for including biological criteria is that it is impossible to enumerate every single contaminant that could possibly elicit biological effects. Rather, it is easier to conduct toxicity tests and have the organisms' physiological reactions to the test indicate whether or not a problem is occurring. Two types of biological criteria were employed for the hot spot remediation: toxicity tests and bioaccumulation.

Toxicity tests

Biological criteria established at Station NBH-2 (the Coggeshall St. Bridge) were designed to prevent water-borne contaminants at levels lethal to organisms from discharging to the lower harbor. The goal of the biological criteria at Station NBH-4 (the Hurricane Barrier) was to prevent water-borne contaminants at levels that might cause sub-lethal effects in organisms from discharging into Buzzards Bay. Based on the results (i.e., species sensitivity) of the pilot study (Nelson and Hansen, 1991), three toxicity tests were selected to assess acute effects at NBH-2 during the hot spot remediation: the sea urchin (Arbacia punctulata) sperm cell test, the 7-day mysid (Mysidopsis bahia) survival test, and the red alga (Champia parvula) survival test. The actual criteria were acute effects greater than 20% that at the West Island reference station (NBH-5) for any two species, or 50% greater than at NBH-5 in any one organism. The toxicity tests selected to assess sub-lethal effects at NBH-4 include the 7-day mysid growth test and the red alga reproduction test. The specific criteria were sub-lethal effects greater than 20% that at the West Island reference station (NBH-5) for any two species, or 50% greater than at NBH-5 for any single organism. These are the same criteria that were employed effectively during the pilot study.

Bioaccumulation

During the preoperational and operational phases of the pilot study, as well as subsequent post-operational deployments, bioaccumulation of PCBs was measured in mussels deployed in NBH. The data indicate that accumulation was remarkably constant over time. However, several questions pertaining to PCB uptake in the mussels were raised as a result of these data. Research was conducted to explore these questions which ultimately reinforced earlier findings that PCB accumulation in mussels accurately reflects water column concentrations, especially the dissolved fraction (Bergen et al., 1993a; 1993b). Therefore, the use of mussels was considered to be very important for monitoring PCB bioavailability at both the Coggeshall St. Bridge and the Hurricane Barrier during remediation. The decision criteria for assessing PCB bioaccumulation at NBH-2 and NBH-4 was a statistically significant (α=0.01) increase over pre-Hot Spot dredging concentrations.

Procedures

Physical

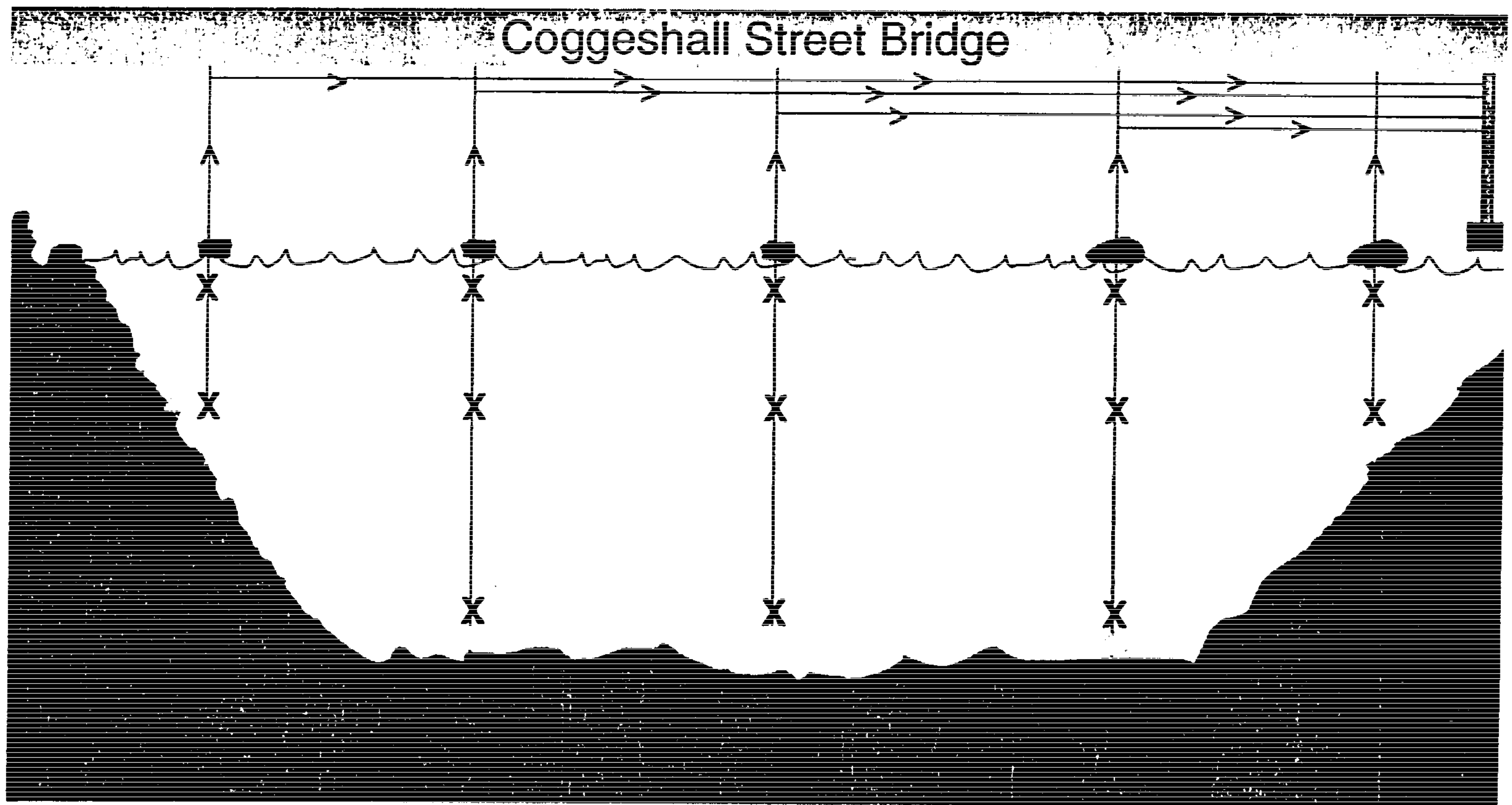
The focal point for water quality monitoring was Station NBH-2, for the reasons mentioned above. Quantifying total PCB-flux to the lower harbor was assessed at this site and represented one of the most important criteria in the project. An intensive water column sampling effort was conducted at NBH-2 during each tidal cycle (i.e., flood tide then ebb tide) when dredging occurred. Water samples were collected at thirteen separate locations throughout the water column at this station (5 horizontal points with multiple depths at each point, see Figure 2-2). Samples were taken at each six-inch fall or rise in tidal fluctuation as measured by a tide gauge at the bridge. Tidal amplitude was used instead of time intervals because water rise and fall at NBH-2 was not uniform over a tidal cycle. These samples were composited to form one sample for the ebb tide and one sample for the flood tide. These two samples were analyzed for PCBs and metals. PCB analysis was conducted on a 24 hour turn-around basis so that contaminant transport to the lower harbor could be assessed rapidly for each dredging day. For cumulative flux determinations, on days when dredging occurred but no monitoring was conducted, the mean concentration of all previous dredging days was used for cumulative flux determinations. Both individual and cumulative flux determinations were reviewed on a daily basis. If elevated contaminant levels were detected, water data were reviewed from NBH-1 and NBH-7 to provide an indication of the contamination source. In addition, the cumulative flux determinations were compared daily to the MCT decision criteria for the entire project.

Chemical

PCBs

The primary remedial goal was to remove PCBs and other collocated contaminants; therefore, accurate quantification of PCB concentrations in water and biota was extremely important. PCBs are a class of hydrophobic organic contaminants containing 209 individual congeners. Each PCB congener has one to ten chlorine atoms attached in a unique molecular arrangement. For many years, PCBs were quantified as total Aroclor®. Aroclor® is

Figure 2-2. Multi-point sampling array at the Coggeshall Street Bridge (station NBH-2).



a Monsanto company trademark and refers to mixtures of PCB congeners (e.g., see Table 3-3). When quantifying total PCB concentration as Aroclor®, results can vary depending upon the analytical method used (i.e., which congeners are selected to represent the Aroclor® mixture). Congener-specific analysis is more accurate because single congener standards and reference materials (with congener-specific certified values) are readily available. For these reasons, this program measured 18 individual congeners in water and biota (Table 2-1), instead of quantifying total Aroclor®. However, because numerous samples collected during the pilot study measured both congener and Aroclor® content, a relationship between the two was calculated that allowed conversion of the PCB congener concentrations to total Aroclor® content.

Another result from the pilot study was how best to quantify PCB concentrations in water column samples. A subset of samples were analyzed for both whole water and dissolved/particulate PCB concentrations. Often, the sum of the dissolved PCB plus particulate PCB exceeded the whole water PCB concentration, particularly during times of increased particle loading. For this reason, and to increase the accuracy of the net transport calculations, all water samples were analyzed for dissolved and particulate PCBs separately, then summed to get a total value.

Water sample PCB analysis was conducted in the following manner. Separate composite samples for the ebb and flood tidal cycles were thoroughly mixed and filtered through a 0.3 um Type A/E Gelman glass fiber filter. An internal standard (CB198) was added to each sample before extraction with acetone and methylene chloride. Extracts were solvent exchanged to hexane and analyzed by GC-ECD (gas chromatograph equipped with an electron capture detector). Eighteen individual PCB congeners were quantified in the dissolved and particulate fractions of the seawater.

Metals

Separate ebb and flood composite samples were thoroughly mixed and filtered through a 0.45 um Coster teflon filter. Next, samples were extracted with 2M nitric acid. The resultant extract was brought to volume and analyzed for As, Cd, Cr, Cu, Hg, Pb, Ni, Se and Zn on an inductively coupled plasma spectrophotometer or an atomic adsorption spectrophotometer.

Biological

Toxicity tests

Arbacia punctulata: The sea urchin, *Arbacia punctulata*, sperm cell test (SCT) measures the concentration of a test substance that reduces fertilization of exposed gametes relative to a control. In this study, the SCT was used to measure water column acute toxicity at station NBH-2. The test method uses fertilization to estimate toxicity, following a short-term

Table 2-1. The eighteen congeners measured in the water column for this study.

Name	Substitution Pattern
CB008	2,4'-
CB018	2,2',5-
CB028	2,4,4'-
CB044	2,2',3,3'-
CB052	2,2',5,5'-
CB066	2,3',4,4'-
CB101	2,2',4,5,5'-
CB105	2,3,3',4,4'-
CB118	2,3',4,4',5-
CB128	2,2',3,3',4,4'-
CB138	2,2',3,4,4',5'-
CB153	2,2',4,4',5,5'-
CB170	2,2',3,3',4,4',5-
CB180	2,2',3,4,4',5,5'-
CB187	2,2',3,4',5,5',6-
CB195	2,2',3,3',4,4',5,6-
CB206	2,2',3,3',4,4',5,5',6-
CB209	decachlorobiphenyl

exposure of the sperm to effluents or receiving water. Briefly, the method consists of exposing dilute sperm solutions to the NBH water samples for one hour. Eggs are added and fertilization occurs in exposure vials. The test is terminated after 20 minutes by the addition of a fixative, and relative fertilization is tabulated by microscopic observations of eggs from control and test samples. Fertilization of the sea urchin egg is readily apparent by the presence of a surrounding fertilization membrane.

Mysidopsis bahia: Mysids are small marine shrimp. The mysid test method consists of exposing seven-day old Mysidopsis bahia juveniles to a water sample for 7 days. Two test endpoints were used in this program; survival, a measure of acute toxicity at NBH-2, and growth (measured as dry weight), a measure of sub-lethal effects at NBH-4. The test was conducted under conditions of daily renewal with NBH water samples, during which the animals were fed newly hatched brine shrimp, Artemia salina.

Champia parvula: This marine red alga was also used to measure both acute and sub-lethal effects during the dredging program. Five replicates were analyzed at each station and the results averaged. At NBH-2, acute toxicity was quantified in water column samples, while at NBH-4, sexual reproduction was measured as a sub-lethal effect. Briefly, the method consists of an exposure of males and females to effluents or receiving waters for two days, followed by a 5- to 7-day period of development in control medium. The latter period allows time for any cystocarps (evidence of sexual reproduction) to mature. At the end of the developmental period, the number of live plants and the number of cystocarps per plant are counted.

Bioaccumulation

Detailed methods for collecting and deploying mussels are found in Nelson and Gleason (1995). Briefly, uncontaminated mussels were collected from East Sandwich, MA (blue mussels, Mytilus edulis) and West Island, MA (ribbed mussels, Modiolus demissus). Both mussel species were utilized because dredging continued throughout the summer months, where water temperatures are often greater than 25°C in the upper harbor. Blue mussels do not survive these temperature for long periods of time, therefore, it was necessary to use another organism. Ribbed mussels have a greater temperature tolerance than blue mussels and a previous study in NBH demonstrated that they accumulate PCBs in concentrations equivalent to that in blue mussels within a 28-day deployment period (Nelson et al., 1995).

Mussels were placed into polyethylene mesh bags and deployed 1 meter above the bottom at three sites:, NBH-2, -4, -5 (Figure 2-1). Each station consisted of four independent satellites. After 28 days, the mussels were retrieved and frozen. Prior to analysis, mussels were thawed, shucked and homogenized. Two grams of homogenate were extracted with acetonitrile and pentane, solvent-exchanged to hexane, and analyzed by gas chromatography for the same 18 PCB congeners quantified in the water samples (Bergen et al., 1993a).

C. Results and Discussion

Net transport

The primary hot spot dredging monitoring goal was to effectively limit the transport of PCBs out from the upper harbor. The MCT decision criterion was established to allow an amount of PCBs that would not require any additional remediation in the lower harbor. Figure 2-3 shows the net transport of PCBs (Kg per day) for each day that transport data were collected. For days when dredging occurred but transport data was not collected, a mean PCB net transport value was used. This value was calculated by taking a mean of all previous dredging days' transport levels. Thus the cumulative net transport values include all dredging days, both when monitoring occurred and when it did not.

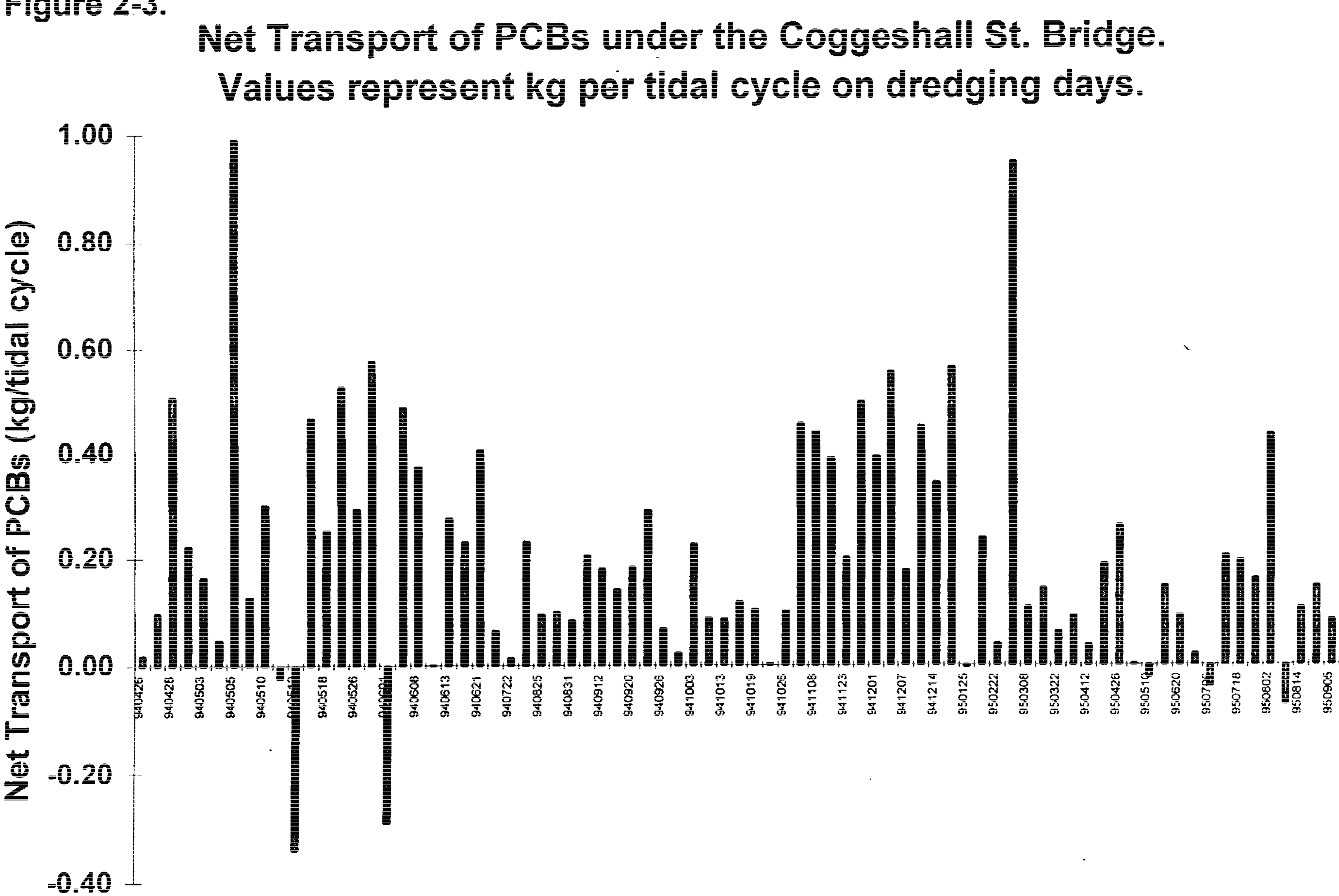
The cumulative transport during the dredging operation never approached the maximum allowable under the decision criteria. Figure 2-4 shows the allowable maximum cumulative transport, 240 Kg, distributed equally over the entire dredging period, 260 days (240 Kg/260 days). Also shown is the actual cumulative transport over the same period. For the entire operation, the total mass of PCBs transported under the bridge was approximately 57 Kg. This represented only 24% of the maximum 240 Kg allowed based on the net transport criterion. Therefore, the criteria for net transport was not violated during the remediation. The mass of PCBs transported out of the upper harbor during this time period was significantly less than that considered sufficient to require additional remediation in the lower harbor.

Toxicity tests

A summary of the biological test results for NBH-2 and NBH-4 is provided in Table 2-2, while Appendix A tabulates all of the biological data. The results of specific test results are discussed here.

Sea Urchin sperm cell test. Of the 86 sperm cell tests performed during the dredging project, mortality at station NBH-2 was never more than 10% than that of station NBH-5 the reference site. At station NBH-4 the maximum difference between station NBH-4 and NBH-5 was 12%. Therefore, because the criteria for mortality (greater than 50% that at NBH-5 for any single species) was never violated during the course of this operation, remedial activities appeared to cause no acute effects based on this test.

Figure 2-3.



Net Transport of PCBs under the Coggeshall St. Bridge.
Values represent kg per tidal cycle on dredging days.
Net Transport of PCBs (kg/tidal cycle)
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
940425
940428
940503
940505
940510
940518
940526
940608
940613
940621
940722
940825
940831
940912
940920
940926
941003
941013
941019
941026
941108
941123
941201
941207
941214
950125
950222
950308
950322
950412
950426
950620
950718
950802
950814
950905

Figure 2-4.

Comparison of actual transport during the Hot Spot Remediation with the maximum allowable under the decision criteria

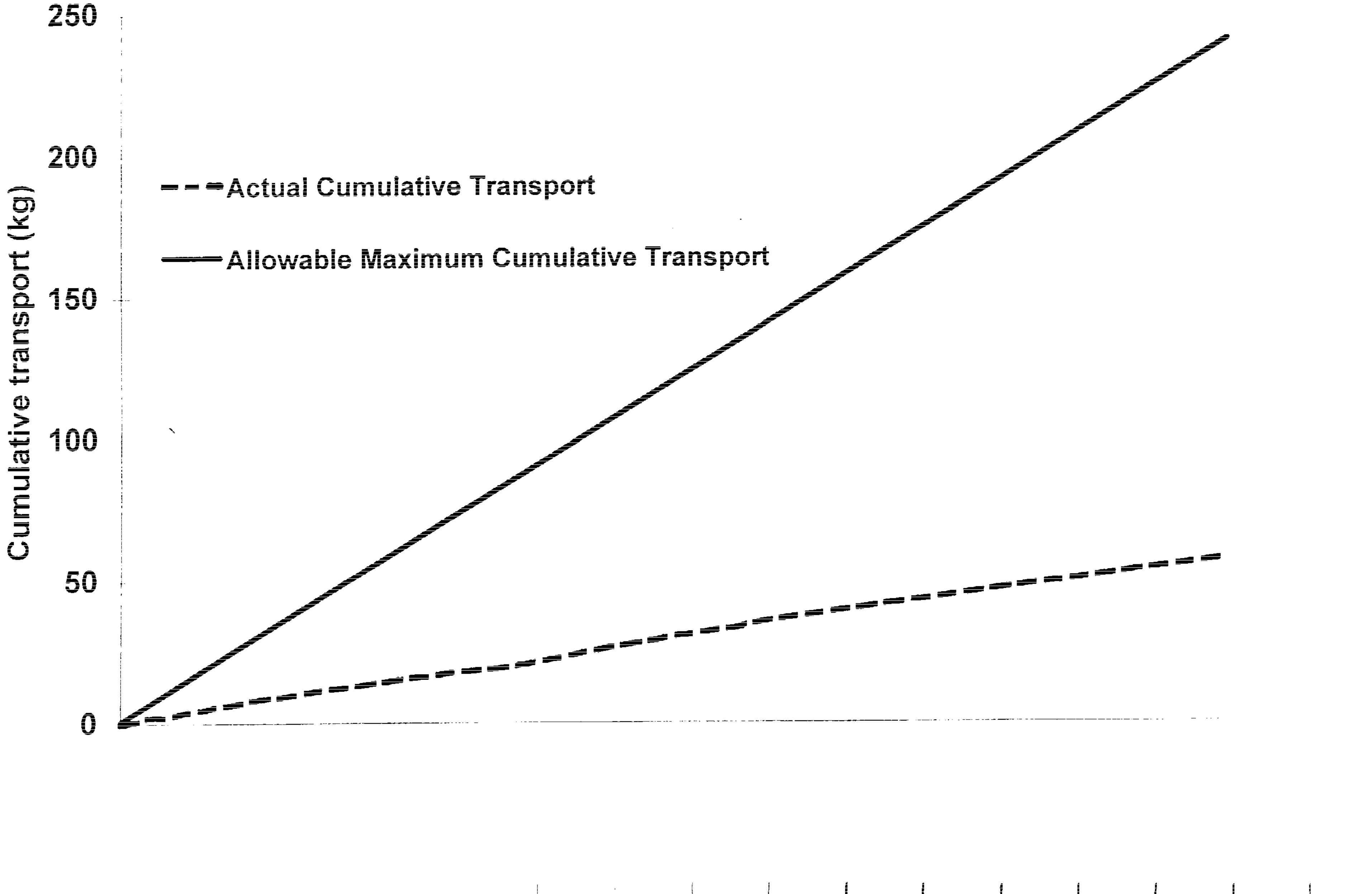


Table 2-2. Synthesis of toxicity test results relative to biological decision criteria. The biological criteria at NBH-2 were mortality >20% that at NBH-5 for any two species, or >50% for any single species. At NBH-4, the criteria were sub-lethal effects >20% that at NBH-5 for any two species, or >50% for any single species. Values indicate the number of times criteria were exceeded for each test, along with the total number of tests conducted, in parentheses, during the hot spot monitoring program.

Station Location	Acute Effects (NBH-2)			Sub-lethal Effects (NBH-4)	
	Sperm Cell Test	Mysid Survival	*Champia* Survival	Mysid Growth	*Champia* Reproduction
NBH-2	0 (86)	1 (7)	1 (83)		
NBH-4	0 (85)	0 (7)	0 (82)	0 (7)	3 (72)

Table 2-3. Mean (standard deviation) PCB concentrations (sum of 10 congeners, ng/g dry weight) in mussels deployed at monitoring stations for 28 days. Pre-Operational samples were collected between July 1987 and December 1993 (n=9); Operational samples were collected between May 1994 and September 1995 (n=14); Post-Operational samples were collected between October 1995 and May 1997 (n=4).

Station	PCB Concentration (ng/g)		
	Pre-Operational	Operational	Post-Operational
NBH-2	15012 (4368)	15052 (4719)	14639 (3715)
NBH-4	3814 (892)	4250 (890)	6315 (711)
NBH-5	613 (187)	403 (73)	371 (204)

Mysids. Seven week-long tests were conducted with mysids, with only one demonstrating any negative impact relative to mysid survival at station NBH-2: 100% mortality occurred during the week of 12/12/94. However, during this same time period, no acute effects were observed with the sea urchin sperm cell test or in Champia survival. Relative to the sub-lethal mysid growth criteria established at NBH-4, no negative effects were observed on any occasion. Based on the specific decision criteria established for this operation, dredging could have had an acute effect on only one occasion; however, similar acute effects were not observed with either of the other two test species.

Champia. Water column samples collected on eighty-five days were assessed for Champia survival at NBH-2. On only one occasion (9/7/94) was mortality greater than 50% that at NBH-5. However, on the same day, survival was 100% and 50%, respectively, at stations NBH-1 and NBH-7, which were closer to the dredging operation. Furthermore, no negative effects were observed in the sea urchin acute test at station NBH-2 on this same day. While the exact reason for this mortality is unknown, the data indicate that it was not related to the dredging operation.

Champia reproduction, as measured by cystocarp production, was one of two tests used to assess sub-lethal effects at NBH-4. Of all the tests used in this monitoring program, Champia reproduction is the most sensitive to both anthropogenic stressors (e.g., metals, organics) as well as natural stressors (e.g., nutrients, temperature). Therefore, while this test provides a comprehensive assessment of overall water quality, the variability associated with the results makes it more difficult to interpret relative to the dredging operation specifically. For example, 12 of the 84 tests showed no reproduction (<1 cystocarp) at any station, including NBH-5, therefore, the test results were only interpretable for 72 days. On 3 of these 72 days, cystocarp production was less than 50% that at NBH-5, the criterion value at NBH-4. However, on one of those days, this criterion was not exceeded at either NBH-1, -7, or -2, therefore, that day's effect cannot be attributed to the dredging operation. The fact that sub-lethal effects were observed in only 2 out of 72 tests (less than 5%) at NBH-4 indicates that any sub-lethal effects due to the remedial dredging operation had a minimal, if any, impact on Buzzards Bay.

Bioaccumulation

PCB accumulation in mussels is shown in Figures 2-5 (NBH-2), 2-6 (NBH-4), and 2-7 (NBH-5). The mean and standard deviation for the three operational phases (preoperational, operational, postoperational) are summarized in Table 2-3. The criteria of a statistically significant increase (α=0.01) in mussel PCB concentration during operational dredging relative to

Figure 2-5: Mean PCB concentrations in blue mussels deployed for 28 days at Station NBH-2. Values on 940808, 940916, 950907 and 951005 are for ribbed mussels.

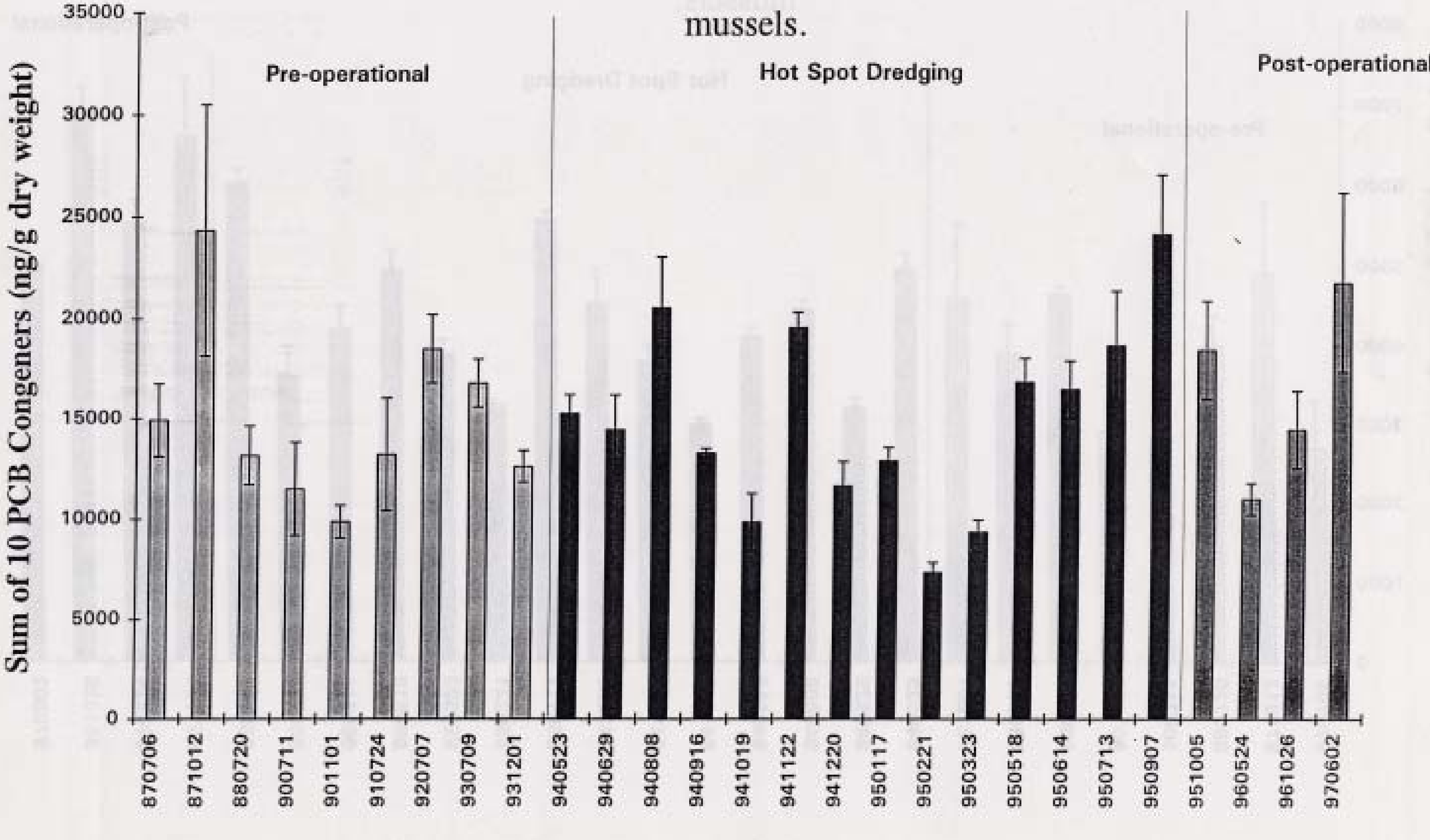


Figure 2-6: Mean PCB concentration in blue mussels deployed for 28 days at Station NBH-4. Values on 940808, 940916, 950907, and 951005 are for ribbed mussels.

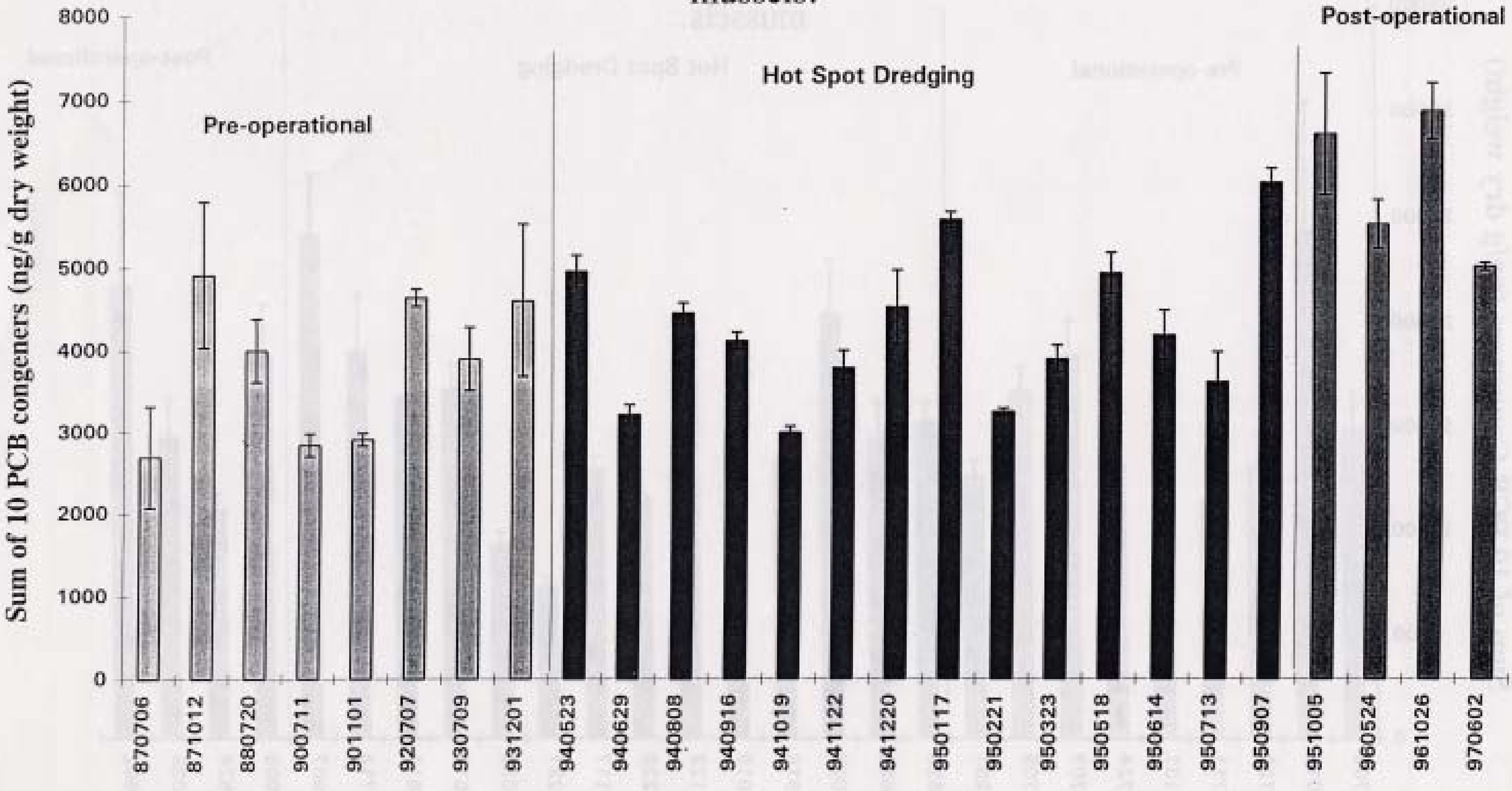


Figure 2-7: Mean PCB concentrations in blue mussels deployed for 28 days at Station NBH-5. Values on 940808, 940916, 950907, and 951005 are for ribbed mussels.

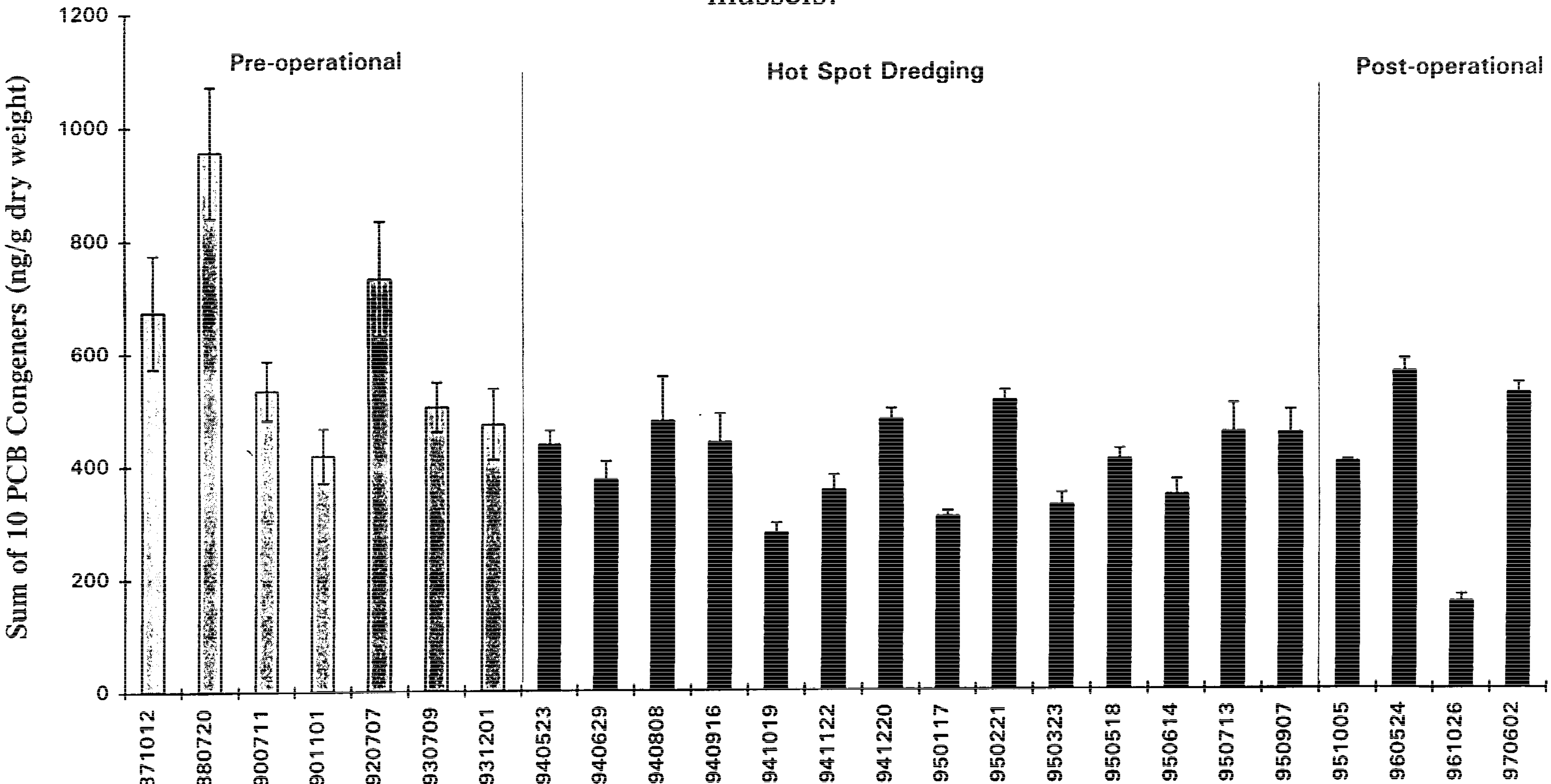
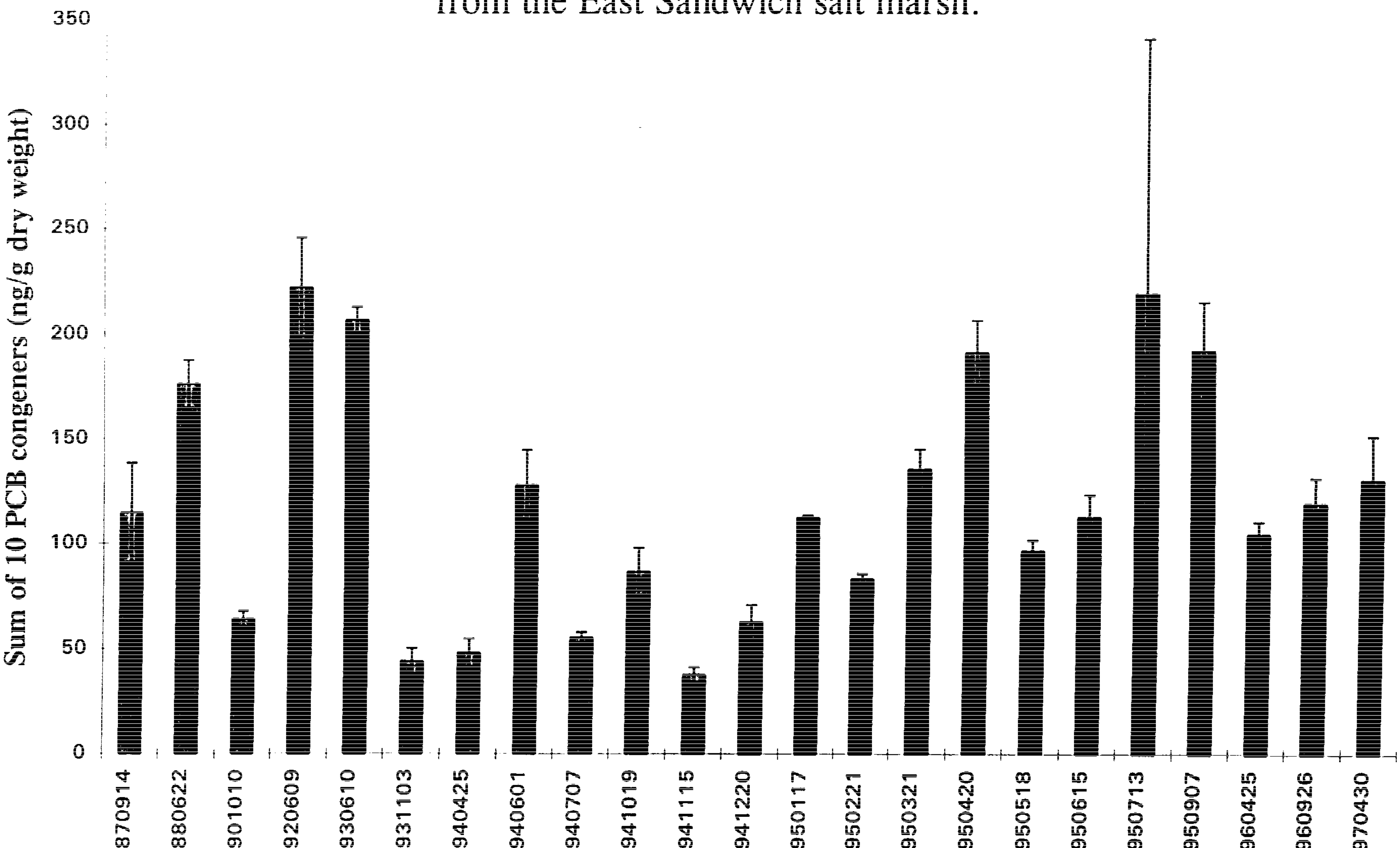


Figure 2-8: Mean PCB concentration in Day-0 blue mussels collected from the East Sandwich salt marsh.



preoperational concentrations, at stations NBH-2 and NBH-4, was never exceeded. There was a statistically significant decrease observed at the reference site (NBH-5) during the remediation; however, this is probably an artifact of two very high preoperational deployments. Typical seasonal variability can be seen during all phases of the hot spot remediation at all stations, including the clean collection site in East Sandwich, MA (Day-0, Figure 2-8). This variability is most likely attributable to spawning, where lipid-rich gametes increase and decrease during the year.

To date, four postoperational deployments have been conducted. At stations NBH-2 and NBH-5, no increase in PCB bioaccumulation has been observed. At station NBH-4, a statistically significant increase was observed. While the cause of this increase is unknown at the time, it is unlikely that it is attributable to the Hot Spot remediation. If this were the case, an increase also would be expected at NBH-2 which is much closer to the actual remedial area. This situation will continue to be monitored over time. Mussels will be deployed twice yearly at these same sites to provide an integrated assessment of water column PCB concentrations as outlined in the NBH Long-term Monitoring Plan (Nelson et al., 1996).

D. Conclusions

Based on an analysis of all the hot spot water quality monitoring data relative to the initial project decision criteria, the remedial dredging operation was completed within the acceptable limits agreed to by EPA, COE, and the Commonwealth of Massachusetts. There was a minimal net transport of PCBs during the dredging project, well below the level calculated to require any additional dredging in the lower harbor. During remediation, there were no acute toxicity effects that could be attributed to the dredging operation. PCB bioaccumulation in mussels was not significantly greater than pre- or post-operational deployments. These results indicate that the hot spot remedial dredging operation had a minimal environmental effect on New Bedford Harbor and Buzzards Bay. In light of the fact that a significant amount of PCBs were removed during this remedial dredging, this operation was successful.